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Using Thermal Imaging to detect energy leakage in existing windows

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Objective

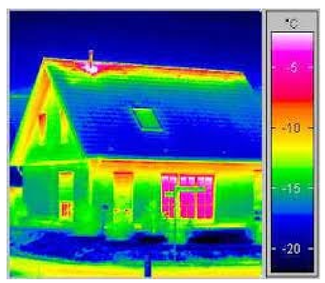
To develop a method for homeowners to assess energy leakage in existing windows that is simple and cost effective. This can be done through the utilization of thermal image (or infrared) photography which can provide information on areas where heat infiltration might me occuring at a glance.

Motivation

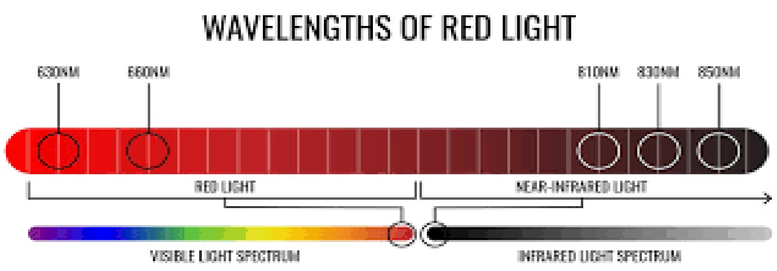
Heat escaping through windows is a energy cost that homeowners can avoid if they can only prevent it.
Energy ratings in new windows provide information about how well windows prevent heat from infiltrating in or out.
The National Fenestration Rating Council is a non-biased entity that provides these ratings to the consumer in the form of an Energy Star sticker that is affixed to new windows.

Energy Star Label on new windows provides information on heat infiltration among other things.

Homeowners with older windows, however, don't currently have a way to find out whether or not their windows are "leaking" heat. They need a simple method for checking whether energy leaks are occurring in their existing windows without having to to go to the expense of hiring a professional.
Since thermal technology interprets light energy as heat and uses colors to represent different temperatures, windows can easily be photographed and visually assessed to see the areas where any infiltration might be occurring.



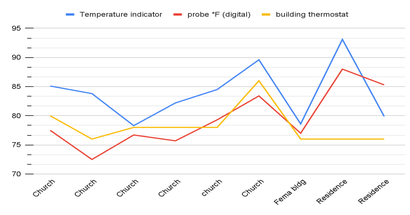
Thermal or infrared imaging interprets heat and interprets varying temperatures as color.



Instead of the 400–700 nanometre (nm) range of the visible light camera, infrared cameras are sensitive to wavelengths from about 1,000 nm to about 14,000 nm

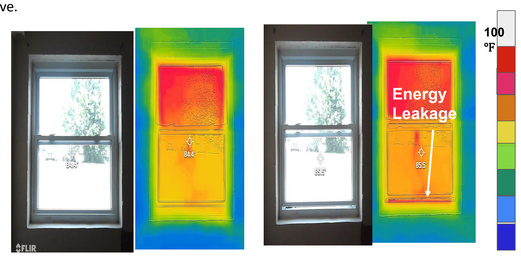
Method

After using a digital probe to determine the validity of the temperature scale, we used a FLIR ONE infrared camera that attaches to aniphone 6, to photograph windows in a FEMA storm shelter, a church, and a residence. These thermal images were compared to others on the same wall to determine whether uneven patterns of heating could be seen at window frames or panes. This would reveal whether energy leakage was occurring. Areas that showed a "hotter" color on the windows were areas of suspected infiltration or leakage.



Temperature reading on camera monitor compared with digital thermometer reading of ambient temperatures along with thermostat reading shows the camera temperature following the same general temperature curve.

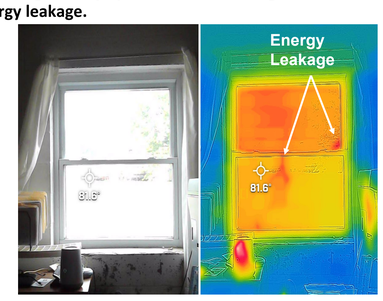
Actual photo of the FLIR ONE camera attached to the bottom of an iphone.6.



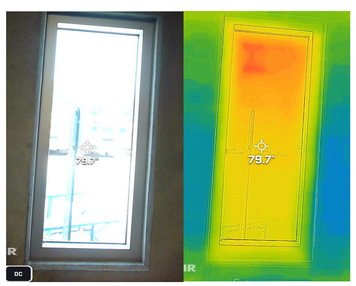
The same window gradually opened from left to right show increasing energy leakage.

Results

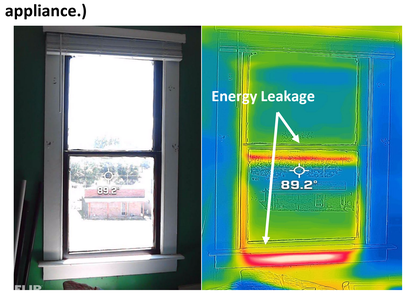
Actual window at church on the left (facing North), when thermally photographed, even pattern shows no indication of energy leaking



This basement window in the same church (facing North) show warmer areas at corner and center of window frame, therefore indicating energy leakage. (Red object in lower left corner is an electronic appliance.)



All windows in newly built FEMA building shows even temperature pattern similar to this, revealing no leakage.



This upstairs window in a residence shows heat infiltration at bottom and top of lower window frame, therefore revealing leakage.

Testing Constraints and limitations

Getting reliable images could be challenging. Roughly 30% of the thermal images of the windows photographed contained "ghosts." These are caused when lower energy infrared bounces off windows and other hard surfaces, onto the photographer, and back to the window. I resolved the problem by taking pictures at about a 60 degree angle. This did not seem to affect the temperature reading on the camera monitor..

same window photographed in infrared with a "ghost."

The FLIR One Third Generation camera that I used doesn't display a temperature scale on the side of the screen to show the full range of temperatures the camera is currently detecting. Also, the spot temperature meter is the only thing that displays numbers and is locked to the center of the screen. The Pro model (about $150 more) allows the user to drag it around the frame with a finger and also is able to display temperature variations at multiple points like frames, window panes, and wall.

Implications

This same method of using infrared, or thermal imaging to detect energy loss in windows can be used to identify leaks in other problem areas of a building like roofs or doors. This would allow homeowners to see and prioritize areas that need more insulation or better seals over those that don't.
Although most people don't have access to an infrared camera, the one that we used (FLIR ONE Generation 3) can be purchased for around $200. An alternative would be to rent a thermal scanner from a do it yourself store like Home Depot for around $75 a day. The cost can be justified by the money saved on energy bills once problem areas are identified and energy leaks are repaired.

Future Work

Also, to make an even faster determination of whether or not energy leakage is occurring in windows or other areas of a building, artificial Intelligence such as Google's Machine Learning can be utilized. Images of windows that show energy leakage as well as those that do not, can be uploaded in order to teach the program to recognize windows that do and do not show infiltration.

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References

https://www.nfrc.org/energy-performance-label/
https://www.flir.com/discover/

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